# What's Killing the Mushrooms of Pennsylvania?

In early spring, after winter-dormant fields have been tilled and seeded, farmers walk over their fields and look for signs of life. They scan the newly furrowed earth for tiny shoots of green and give a small sigh of relief when they find them.

Most farmers, that is.

If there's one thing a farmer of mushrooms fears, it's seeing the color green in his or her crop beds. Mushrooms are fungi and lack chlorophyll. Instead of relying on the sun and photosynthesis, they draw their nutrients from the ground and their growing medium. Healthy colors for the most popular commercially grown mushrooms in the United States are white, brown, and beige. Green spells disease. For mycologists with the Agricultural Research Service's Systematic Botany and Mycology Laboratory (SBML) in Beltsville, Maryland, green also spelled a challenge not long ago.

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**Mycologist Gary Samuels and University of Maryland student Lutorri Ashley discuss the morphology of the *Trichoderma* that causes green mold of mushrooms.**

In the early to mid-1990s, mushroom farmers in Pennsylvania were under siege. Commercial production of their crop was being seriously affected by a green mold epidemic. According to the National Agricultural Statistics Service, Pennsylvania farmers grow more mushrooms than farmers in any other state, and in 1995 the farmers in Chester County—the state's mushroom mecca—experienced crop losses of 30 to 100 percent.

Initially, scientists identified the culprit as *Trichoderma harzianum,* a common fungal species used commercially in the biological control of other fungi that induce plant diseases, including Botrytis gray mold. It also has the potential to enhance plant growth and has been credited with degrading pesticides in soil and preventing mycotoxin synthesis.

But if *T. harzianum* were the fungus causing the green mold epidemic, its commercial viability would be in jeopardy: It would be attacking a valuable and popular food commodity.

## Mushroom Love

Americans love mushrooms, now more than ever. Per capita consumption in the United States increased from 3.7 pounds in 1993 to 4.2 pounds in 2000. Sales of the 2001-2002 U.S. mushroom crop totaled 851 million pounds, and consumers spent $912 million on them. Mushrooms are a good source of selenium, potassium, and copper, and some types have significant amounts of three B-complex vitamins. In a fight between the commercial production of mushrooms and the commercial production of *T. harzianum,* mushrooms would win.

But the mycologists at SBML were not so sure that the beneficial biocontrol fungus *T. harzianum* was to blame. They looked at the green mold problem and saw that not just one, but four distinct *T. harzianum* biotypes had been identified as the cause. And only two of those could be associated with appreciable mushroom loss.

Says Gary Samuels, an SBML mycologist and world-renowned *Trichoderma* expert, "We suspected that the four biotypes identified as causing the green mold epidemic might not all be from the same species. A few studies suggested genetic distinctions between them, but no one had studied the differences closely."

That's when the systematic expertise of SBML researchers came into play. Systematics is the science of classification, and the researchers at SBML focus on describing and classifying fungi and plants. They use morphological (structural), biochemical, and molecular data to identify and characterize agriculturally important species and sort out their relationships.

## The Aggressive Mold

Samuels and SBML mycologist Sarah Dodd examined 99 strains of the 4 *Trichoderma* biotypes found in cultivated mushroom beds. Only two biotypes were associated with mushroom loss; the other two were benign. SBML studies confirmed others' findings that the benign biotypes were the real *T. harzianum* and *T. atroviride*—a common, nonpathogenic fungus.

"There were consistent genetic differences between the biotype we knew to be *T. harzianum* and the two biotypes that were causing the mushroom losses," says Dodd. She compared all four biotypes through molecular analysis, using particular sequences from their nuclear ribosomal DNA and a protein-coding gene called EF-1-alpha.

Samuels says, "The differences are detectable at more than just the molecular level. We could also distinguish the benign fungi by their rate of growth and odor. For example, only the real *T. harzianum* grows well and forms spores at 35˚C [95˚F]. And *T. atroviride* has a characteristic coconut odor."

Through their morphologic and molecular studies, the SBML researchers were able to exonerate *T. harzianum* and to name a new *Trichoderma* species as the mushroom killer.

"As we suspected, the two strains of *Trichoderma* causing damage to cultivated mushrooms aren't from the species of good biological control fungi," says Samuels. "They're from a different species altogether." The scientists named the

new species *T. aggressivum* because of its aggressive nature.

An article containing a description of *T. aggressivum* and expanded descriptions of *T. harzianum* and *T. atroviride* appeared in the January 2002 issue of *Mycologia*.—By **Amy Spillman,** ARS.

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### Little-Known Mushroom Facts

•One portabella mushroom has more potassium than a banana; white and crimini mushrooms are also good sources. Potassium helps the human body maintain normal heart rhythm, fluid balance, and muscle and nerve function.

•Mushrooms contain significant amounts of selenium, which plays an important role in the immune system, thyroid system, and male reproductive system. It also works closely with vitamin E to produce antioxidants that help the body fight cell-damaging free radicals.

•Mushrooms are an excellent source of copper, a mineral that the body needs to produce red blood cells and for other functions.

•Mushrooms have significant amounts of three B-complex vitamins—riboflavin, niacin, and pantothenic acid—particularly riboflavin. The B vitamins help release energy from the fat, protein, and carbohydrates in food.

•Truffles, or subterranean mushrooms, are the world's most expensive vegetable. One variety, *Tuber melanosporum,* can cost between $800 and $1,500 a pound.

•The largest living organism ever found is a honey mushroom, *Armillaria ostoyae*. It covers 3.4 square miles of land in the Blue Mountains of eastern Oregon, and it's still growing.

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**Per capita U.S. consumption of mushrooms increased from 3.7 pounds in 1993 to 4.2 pounds in 2000. These button mushrooms are a favorite in or on soups, salads, pizza, and many other dishes.**